II. WHAT ARE TYPICAL CAUSES OF MOISTURE PROBLEMS IN HOMES?

Through breathing and normal daily activities, each member of a household produces about seven pounds of water vapor. Naturally this number varies greatly depending on living habits. This water vapor becomes part of the air. However, air can hold only a limited amount of water vapor. This amount depends on temperature. The higher the temperature the more moisture the air can hold. When more moisture is introduced into the air than it can hold, some of the moisture will condense on surfaces. If cold surfaces sufficiently cool the surrounding air, condensation will occur on that surface even though the remaining room air is not saturated with moisture. The frosted cold beverage glass in summer is an example.

In most older homes there is enough movement of air into and out of the house that moisture does not build up and only small amounts of condensation occurs. However, when air leaks into and out of a house it not only takes moisture but heat as well. In order to make homes more energy efficient, builders have been trying to seal cracks and cut air leaks.

These efforts to tighten homes have meant that more moisture remains in the home. Unless controlled ventilation is added, moisture accumulates, and condensation occurs near the ceiling on outside walls or on outside walls of closets. These areas generally have cooler surfaces. If condensation persists on these surfaces, molds and mildews may develop. In addition, fungal growth and possible deterioration of material may occur when temperatures are at or above 50°F and the material remains wet. Such fungal growth could damage wood members in extreme circumstances.

III. BESIDES THE UDC REQUIREMENTS, WHAT MEASURES CAN HELP PREVENT MOISTURE PROBLEMS?

A. REDUCE MOISTURE PRODUCTION IN THE HOME

One way to substantially reduce the chances that condensation will occur either on inside surfaces or within walls is to keep indoor moisture levels low. The first step is to reduce the amount of moisture produced in the home. Some major sources of moisture that can be controlled are listed below.

1. *Prevent moisture from entering through basements. Many basements feel damp in the summer due to condensation of moisture from the air on cool basement surfaces. However, in some cases damp basements may be due to ground moisture entering the home through basement walls. Cracks or stains on basement walls and floors are signs of dampness entering through these surfaces.*

   You can check whether dampness is coming through walls by using a simple patch test. Tape a piece of plastic sheeting tightly against the basement wall where you suspect moisture penetration. After a couple of days pull the patch off *and look for signs of moisture on the wall side of the patch. If you detect moisture, it means moisture is coming through the wall rather than condensing on the walls.*

If you suspect a basement water problem, check the surface drainage around you home. Most basement water problems result from poor surface drainage. Make sure that the ground slopes away from the foundation. Consider installing gutters. If you have gutters, make sure they are clear of debris and functioning properly. Downspouts should direct water away from the foundation.

2. *Do not store large amounts of firewood in the basement. Even seasoned wood can contain large amounts of moisture. It also may be a source for fungus.*

3. *Other ways you can reduce moisture generation:*
   a. *Vent clothes dryers outdoors;*
   b. *Don't line dry clothes indoors;*
   c. *Limit the number of houseplants;*
   d. *Cover kettles when cooking;*
   e. *Limit the length of showers; and*
   f. *Do not operate a humidifier in the wintertime unless your indoor relative humidity is below 25 percent.*
   g. *Be sure any crawlspace floors have a vapor retarder covering.*

4. *If problems persist, you should also check for any blocked chimney flues that may be preventing moisture-laden flue gasses from exhausting out of the house.*

5. *Correct any plumbing and roof leaks. If ice dams are a problem, consider more attic ventilation and adding insulation.*

B. ADD MECHANICAL VENTILATION

A second way to reduce moisture levels is to add mechanical ventilation. As an added benefit, ventilation will reduce concentrations of other possible air contaminants such as combustion by-products from heating, cooking and smoking.

A widely recommended ventilation rate for homes is one half air change per hour. In a 1,200-square-foot house with 8-foot high ceilings, there are about 9,600 cubic feet of air. To meet the ventilation standard, half of that amount or 4,800 cubic feet of air must be exchanged every hour. This roughly equals 100 cubic feet per minute (cfm) of air exchange. Even in a tight house some of this air exchange occurs naturally.

However, in a house that is experiencing severe moisture problems, it can be assumed you are getting less than one half air change per hour. A balanced ventilation system should be used to make up the remaining necessary air exchange. A balanced system is one that not only exhausts stale air but provides a source of fresh replacement air.

Currently the UDC only mandates that40% of exhaust ventilation be made up through another mean . Without proper replacement air the home could have what is known as negative air pressure.

Negative pressure could cause exhaust gases from your furnace, which should be going up your chimney or out a vent, to be sucked into the living space.

Additional ventilation is needed only during the heating season. When you provide controlled ventilation for your home, the heat lost is relatively small. For a 1,200-square-foot home, the cost of this lost energy and the electricity to run the fan would amount to about a dollar a day assuming you heat with the most expensive heat source, electric baseboard. This cost should be much less if you heat with gas or other fuels. Also, some ventilation systems can reclaim a portion of the heat (up to 80%) from the exhaust air. This could help reduce energy costs.

C. STOP MOISTURE AT THE INSIDE WALL SURFACE (IN ADDITION TO THE REQUIRED MOISTURE VAPOR RETARDER)

In addition to reducing moisture levels of the interior air, carefully seal all openings in the inside surface of all exterior walls to prevent moist air penetration. This includes joints around window and door casings, baseboards, electrical outlets and switches and any other penetrations.

Vapor Retarders Not on Warm Side

Occasionally it occurs that a wall will have two materials/layers that may act as vapor retarders. It is important in this situation that the better vapor retarder (lower perm rating) be placed closer to the warm side. Also, extreme care should be taken to make the interior vapor retarder continuous with good joint and penetration sealing. This will help avoid condensation of moisture in the wall.

In some other dwelling designs, double walls are constructed with insulation in both walls. Often this is to avoid making electrical box and other penetrations in the vapor retarder. A single vapor retarder is placed between the two walls. This conflicts with the requirements that vapor retarders be placed on the warm side of all insulation. However it may be acceptable depending on the distribution of the insulation between the two walls. If there is enough insulation on the exterior side of the vapor retarder, the air temperature in the insulation at the interior face of the vapor retarder may still be warm enough to prevent condensation.

A DEW POINT CALCULATION estimates expected temperatures throughout the thickness of the wall. Interior temperature, exterior temperature, and wall component R-values must be known. Additionally, a "design" interior air relative humidity must be assumed. Since typical wintertime reported indoor humidities range from 40 percent to 60 percent, the department will accept 50 percent as an average indoor relative humidity (RH) design value for such a calculation.

In order to do such a calculation, a person must have access to a psychrometric chart or table to determine dew points throughout the wall section given specific design temperatures, RH, and wall component R-values.

Example: Fictional Wall
R = 10, uniformly distributed across thickness of 4 inches
RH = 50% (interior)
Temp = 70° interior
-10° exterior

This would result in condensation if interior air was lowered in temperature or exposed to a surface temperature of approximately 50°. In this wall, the 50° dew point occurs at 1 inch from the interior surface. Therefore, a recessed vapor retarder must be to the inside of this 1-inch limit.

Detailed calculations shall be submitted for each specific project where a designer wishes to recess a vapor retarder into the wall cavity.

Basement Floors

***Question**: Is a vapor retarder required under concrete slabs?*
***Answer**: Yes. The vapor retarder is required to be provided under slab-on-grade as well as basement floors.* **Unheated** *garages are exempted.*

Box Sills

***Question**: Is a vapor retarder required over insulation in the box sill?*
***Answer**: This section requires that a vapor retarder be provided wherever thermal insulation is installed. The department has conceded that a vapor retarder would not be effective in the box sill areas because of the numerous joints involved. A good alternative in this area would be rigid foam board or foamed-in-place insulation.*

Paint as a Vapor Retarder

Advances in paint chemistry have made certain paints available to contractors which, when appliid at conventional spread rates, provide a vapor retarder with a perm of 1 or lower.

This department has reviewed vapor retarder paints for application meeting the intent of s. Comm 22.22; however,does not recommend them. The evaluation method used to determine the acceptability of the paint is based on the paint's:

1. *Perm rating based on ASTM test E-96.*

2. *Scrubability as based on ASTM test D-2486.*

3. *Evaluation of manufacturer's recommendation for the paint's use.*

4. *Labeling of all paint containers.*

All test results submitted shall be from recognized independent testing agencies. The department feels that the above assures that specifically reviewed manufacturer's products will perform and not break down when applied as instructed by the manufacturer.

Two coats of vapor retarder paints are required to take into account variances in field application. Also any texturing must be applied after the vapor retarder paint.

In order to assure building officials and owners that a vapor retarder paint has in fact been installed and the intent of s. Comm 22.22 met, a certificate of compliance (see following sample certificate) may be filled out and submitted to the building official with a copy to the owner. In addition to the certificate, the contractor should provide the inspection agency with the labels from the paint cans that were used by the applicator.

The following is the recommended procedure to be followed by building inspection agencies to assure compliance with the vapor retarder requirement and yet to allow limited use of vapor retarder paint. Procedure to be followed:

1. *At the time of plan submittal, the builder should state or have shown on the plans what type of vapor retarder is to be used in the dwelling. Either manufacturer's data or a Wisconsin Materials Evaluation number shall be presented to show compliance by the chosen paint.*

2. *At the time the plan is reviewed, the inspector should provide a blank Certificate of Application if one will be locally required.*

3. *At the time the rough energy inspection is made, the inspector will be able to determine where the standard vapor retarder was applied in the dwelling.*

4. *At the final inspection, the contractor should supply to the building inspector the completed certificate as well as the labels from the paint cans.*

5. *The inspector may then destroy the labels and the Certificate of Application can be filed with the building file.*

Relative Humidity

In winter, the ideal relative humidity range for comfort is 30 percent - 45 percent. A lower humidity may cause excessive skin evaporation which in turn will cause an undesired cooling effect. For the sake of protecting the structure from damage due to excessive moisture, an ideal relative humidity range of less than 45 percent is recommended. Therefore, to provide comfort *and still protect the building, a relative humidity range of 30 percent - 45 percent is recommended.*

In summer, the ideal comfort range is 30 percent - 50 percent. Higher humidity won't allow adequate skin evaporation and the resulting desired cooling effect.

Ventilation

The code requirements of these sections for venting areas are based on effective venting area. Louvers and screening greatly decrease the effective venting of attic vents. Usually the effective venting area of a vent is indicated on it. Otherwise the following is a guide:

Obstruction in Ventilator (Louvers and Screens)	To Determine Total Free Area of Ventilator Multiply Gross Area by:
1/4 inch mesh hardware cloth	1
1/8 inch mesh screen	0.8
No. 16 mesh insect screen (with or without plain metal louvers)	0.5
Wood louvers and 1/4 inch mesh hardware cloth	0.5
Wood louvers and 1/8 inch mesh screen	0.44
Wood louvers and No. 16 mesh insect screen	0.33

Regarding turbine vents, the effective area is equal to the bottom opening area.

Regarding power vents, manufacturer's requirements should be followed. Otherwise an installed mechanical ventilation capacity of 0.25 cfm per square foot of attic floor area is acceptable. Additionally, adequate air intakes must be provided. Control of the fan must be provided by a humidistat or combination humidistat/thermostat. A humidistat setting of 90 percent is acceptable.

VAPOR RETARDER PAINT
CERTIFICATE OF APPLICATION

THIS CERTIFIES THAT A VAPOR RETARDER PAINT HAVING A PERM RATING BELOW 1.0 WAS APPLIED TO THE FOLLOWING STRUCTURE:

____
____

PAINT MANUFACTURER: ____

COMMERCE MATERIAL APPROVAL NO. (If Applicable)

SUPPLIER: ____

GALLONS USED: _________________________ LABELS SUBMITTED: ☐ YES ☐NO

CEILINGS - TOTAL SQUARE FEET COVERED: ___________________________________

WALLS - TOTAL SQUARE FEET COVERED: _____________________________________

NUMBER OF GALLONS USED ON: 1st COAT _____________ 2nd COAT ____________

APPLICATION MADE BY NAME: ____

ADDRESS: ____

SIGNATURE: ____

Comm 22.23 Walls.

(1) GENERAL. The combined thermal transmittance value (U_o) of the gross area of exterior walls shall not exceed the value given in Table 22.21. Equation 1 in s. Comm 22.31 (1) shall be used to determine acceptable combinations to meet this requirement.

(2) METAL STUD FRAMING. When metal stud framing is used, the value of U_w used in Equation 1 in s. Comm 22.31 (1) shall be recalculated using a series-parallel heat flow path procedure to correct for parallel path thermal bridging. The U_w for purposes of Equation 1 in s. Comm 22.31 (1), of metal stud walls shall be determined as follows:

$$U_w = \frac{1}{R_1 + \left(R_{ins} \times F_c\right)}$$

where:

R_1 = the total thermal resistance of the elements, in series along the path comprising the wall

assembly of heat transfer, excluding the cavity insulation and the metal stud.

R_{ins} = the R-value of the cavity insulation.

F_c = the correction factor listed in Table 22.23.

TABLE 22.23
F_c VALUES FOR WALL SECTIONS WITH METAL STUDS PARALLEL PATH CORRECTION FACTORS

SIZE OF MEMBER	SPACING OF FRAMING INCHES	CAVITY INSULATION R-VALUE	CORRECTION FACTOR
2 X 4	16 o.c.	R - 11	0.50
		R - 13	0.46
		R - 15	0.43
2 X 4	24 o.c.	R - 11	0.60
		R - 13	0.55
		R - 15	0.52
2 X 6	16 o.c.	R - 19	0.37
		R - 21	0.35
2 X 6	24 o.c.	R - 19	0.45
		R - 21	0.43
2 X 8	16 o.c.	R - 25	0.31
2 X 8	24 o.c.	R - 25	0.38

Comm 22.24 Roof and ceiling.

The combined thermal transmittance value (U_o) of the gross area of the roof or ceiling assembly shall not exceed the value given in Table 22.21. Equation 2 in s. Comm 22.31 (1) shall be used to determine acceptable combinations to meet this requirement. Skylight shafts, 12 inches in depth or greater, shall be provided with cavity insulation of R-13 and continuous insulation over framing of R-5, or have an equivalent assembly U-value.

Comm 22.25 Floors over unheated spaces.

The combined thermal transmittance value U_o of the gross area of floors that are over unheated spaces and of floors over outdoor air, such as overhangs, shall not exceed the values given in Table 22.21. Equation 3 in s. Comm 22.31 (1) shall be used to determine acceptable combinations to meet this requirement.

Comm 22.26 Slab-on-grade floors.

(1) Where the perimeter edge of a slab-on-grade floor is above grade or less than 12 inches below the finished grade, the thermal resistance of the insulation around the perimeter of the floor shall not be less than the value given in Table 22.21.

(2) Insulation shall be placed on the outside of the foundation or on the inside of a foundation wall. The insulation shall extend downward from the top of the slab for a minimum of 48-inches or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a minimum total distance of 48-inches.

(3) Horizontal insulation extending outside of the foundation shall be covered by pavement or by soil a minimum of 10 inches thick. The top edge of insulation installed between the exterior wall and the edge of the interior slab may be cut at a 45 degree angle away from the exterior wall.

Comm 22.27 Crawl space walls.

(1) If the crawl space does not meet the requirements of s. Comm 22.25 and does not have ventilation openings which communicate directly with outside air, then the exterior walls of the crawl space shall have a thermal transmittance value not exceeding the value given in Table 22.21.

(2) (a) The vertical wall insulation shall extend from the top of the wall to at least the inside ground surface.

(b) Where the vertical wall insulation stops less than 12 inches below the outside finish ground level, crawl space wall insulation shall extend horizontally and vertically downward a minimum total distance of 24 inches linearly from the outside finish ground level.

Comm 22.28 Basement walls.

(1) Except as provided in subs. (3) and (4), the exterior walls of basements below uninsulated floors shall have a transmittance value not exceeding the value given in Table 22.21.

(2) (a) Except as provided in par. (b), the insulation shall extend to the level of the basement floor.

(b) Changes in the exterior insulation area and basement wall minimum thermal transmittance may be included as part of a tradeoff allowed under the method of design by system analysis or other approved compliance method.

(c) If interior insulation is used for code compliance, it shall extend the full height of the wall from basement floor to the underside of the joists above unless tradeoffs are justified by supporting calculations that consider lateral heat conduction in the wall.

(3) Where the total gross basement wall area is less than 50 percent below grade, the entire wall area, including the below-grade portion, is included as part of the gross area of exterior walls.

(4) For the purpose of determining compliance with dwelling envelope performance requirements, non-opaque areas, including windows and doors, of all basement walls shall be included in the gross area of exterior walls.

Comm 22.29 Masonry veneer.

When insulation is placed on the exterior of a foundation supporting a masonry veneer exterior, the horizontal foundation surface supporting the veneer is not required to be insulated to satisfy the foundation insulation requirement.

Comm 22.30 Air leakage.

(1) GENERAL. The requirements of this section apply to those dwelling components that separate interior dwelling conditioned space from the outdoor ambient conditions, or unconditioned spaces such as crawl spaces, and exempted portions of the dwelling from interior spaces that are heated or mechanically cooled. The requirements are not applicable to the separation of interior conditioned spaces from each other.

(2) WINDOW AND DOOR ASSEMBLIES. (a) *General.* Except as specified in par. (b), window and door assemblies installed in the building envelope shall comply with the following maximum infiltration rates, determined in accordance with ASTM E 283:

1. Windows and sliding doors shall have a maximum infiltration rate of 0.3 cfm per square foot of window area.

2. Swinging doors shall have a maximum infiltration rate of 0.5 cfm per square foot of area of the door assembly.

(b) *Exception.* Site-constructed doors and windows shall be sealed with gasketing or weatherstripping or shall be covered with a storm door or storm window.

(3) JOINT AND PENETRATION SEALING. (a) Exterior joints, seams or penetrations in the dwelling envelope, that are sources of air leakage, shall be sealed with durable caulking materials, closed with gasketing systems, taped, or covered with moisture vapor permeable house wrap. Exterior joints to be treated include all of the following:

1. Openings, cracks and joints between wall cavities and window or door frames.

2. Between separate wall assemblies or their sill-plates and foundations.

3. Between walls, roof, ceilings or attic, ceiling seals, and between separate wall panel assemblies.

4. Penetrations of utility services through walls, floor and roof assemblies, and penetrations through the wall cavity of top and bottom plates.

(b) Sealing shall be provided around tubs and showers, at the attic and crawl space panels, at recessed lights and around all plumbing and electrical penetrations, where these openings are located in the dwelling envelope between conditioned space or between the conditioned space and the outside.

Air Infiltration Barrier

The UDC does not define or limit the types of materials to be used as an infiltration barrier. It does require them to:

1. *Be installed on the exterior side of the envelope insulation.*

2. *Form a continuous surface over the walls of the building from the bearing points of the roof to the top of the foundation.*

3. *Seal all seams, joints, tears, and punctures.*

Additionally, the department feels such infiltration barrier construction:

1. *Be water vapor permeable to prevent moisture problems within the wall. The perm rating must be significantly higher than the interior vapor retarder.*

2. *Restrict infiltration to an appreciable extent.*

A specific Department of Commerce materials approval, per s. COMM 20.18, is not required for such materials due to the lack of clear code definition. However, the department has indicated that certain infiltration barrier constructions are acceptable.

These include:

- *Spun bond polyolefin sheets, with taped joints. (Ex: Tyvek by Dupont.)*

- *Micro-perforated polyethylene (Valeron) film sheets, with taped joints. (Ex: Air Stop by Diversi-Foam Products.)*

- *Tongue and groove extruded polystyrene, with taped joints.*

- *Other building panel sheets such as foam sheathing or plywood sheathing with taped joints, regardless if the panels have butt or tongue and groove edges*

Comm 22.31 Calculations.
The following equations shall be used as specified in this chapter:

(1) EQUATION 1.

$$U_0 = \frac{(U_w A_w) + (U_g A_g) + (U_d A_d)}{A_0}$$

where:

U_o = the overall thermal transmittance of the gross exterior wall area.
A_o = the gross area of the exterior walls.
U_w = the overall thermal transmittance of the various paths of heat transfer through the opaque exterior wall area.
A_w = area of exterior walls that are opaque.
U_g = the thermal transmittance of the windows.
A_g = the area of all windows within the gross wall area.
U_d = the thermal transmittance of the door area.
A_d = door area.

(a) When more than one type of wall, window or door is used, the *U* and *A* terms for those items shall be expanded into sub-elements as:

$$(U_{w1}\ A_{w1}) + (U_{w2}\ A_{w2}) + (U_{w3}\ A_{w3}) \text{ (etc.)}$$

(b) Unless exact areas are calculated, the gross exterior wall area with framing 24 inches on center shall be assumed to be at least 22% framing area, and the gross exterior wall area with framing 16-inches on center shall be assumed to be at least 25% framing area.

(2) EQUATION 2.

$$U_0 = \frac{(U_R A_R) + (U_S A_S)}{A_0}$$

where:

U_o = the overall thermal transmittance of the roof and ceiling gross area.
A_0 = the gross area of the roof and ceiling assembly.
U_R = the thermal transmittance of all elements of the opaque roof and ceiling area.
A_R = the gross area of the opaque roof and ceiling assembly.
U_S = the thermal transmittance of the area of all skylight elements in the roof and ceiling assembly.
A_S = the area, including the frame, of all skylights in the roof and ceiling assembly.

(a) When more than one type of roof or ceiling, skylight or door is used, the U and A terms for those items shall be expanded into sub-elements as:

$$(U_{R\ 1}\ A_{R\ 1}) + (U_{R\ 2}\ A_{R\ 2}) + \text{(etc.)}$$

(b) Access doors, hatches, plenums, or other areas in a roof and ceiling assembly shall be included as a sub-element of the roof and ceiling assembly.

(c) Unless exact areas are calculated, wood frame ceilings shall be assumed to be 7% framing area for joists 24-inches on center and 10% framing area for joists 16-inches on center.

(3) EQUATION 3.

$$U_0 = \frac{(U_{f1} \times A_{f1}) + (U_{f2} \times A_{f2}) + (U_{fn} \times A_{fn})}{A_0}$$

where:

U_o = the overall thermal transmittance of the floor assembly.
A_o = the gross area of the floor assembly.
U_{fn} = the thermal transmittance of the various heat transfer paths through the floor.
A_{fn} = the area associated with the various paths of heat transfer.

(a) Unless exact areas are calculated, wood frame floors shall be assumed to be 7% framing area for joists 24-inches on center and 10% framing area for joists 16-inches on center.

(b) Access doors or hatches in a floor assembly shall be calculated as a separate element of the floor assembly using equation 3.

(4) ACCURACY OF CALCULATIONS. The thermal transmittance (U_o) values and dwelling dimensions used in heat gain or loss calculations shall have a minimum decimal accuracy of 3 places rounded to 2, except that the U_o values used for calculating ceiling transmission shall have a minimum decimal accuracy of 4 places rounded to 3.

(5) VALUES. Unless otherwise specified in this chapter, the thermal transmittance and resistance values used in heat gain and loss calculations shall be determined by one of the following methods:

(a) The values shall be those given in the ASHRAE Handbook of Fundamentals as adopted under s. Comm 20.24 (8).

Note: See the appendix under "Typical Thermal Properties of Building Materials" for the ASHRAE values.

(b) 1. Testing to a nationally recognized test standard by an independent third party that is submitted for department review and approval under s. Comm 20.18.

2. The testing shall verify the claimed thermal resistance for the specific application of the product or assembly.

3. For foam plastic insulation that uses a blowing agent other than air, the independent third-party tests shall use samples that have been aged for the equivalent of 5 years or until the R-value has stabilized.

Note: See Appendix for a table of R-values reprinted from the ASHRAE Handbook of Fundamentals.

Comm 22.32 Recessed lighting fixtures.

When installed in the dwelling envelope, recessed lighting fixtures shall meet any one of the following requirements:

(1) The fixture shall be inherently or thermally protected type IC and installed inside an air-tight assembly maintaining any clearances required by the listing.

(2) The fixture shall be inherently or thermally protected type IC, manufactured with no penetrations between the inside of the recessed fixture and ceiling cavity, and sealed or gasketed to prevent air leakage into the unconditioned space.

(3) The fixture shall be inherently or thermally protected type IC, and labeled as being tested in accordance with ASTM E 283 at a pressure difference of 75 pascals or 1.57 lb/ft^2 with no more than 2.0 cfm air movement from the conditioned space to the ceiling cavity.

Subchapter VII — Design by Systems Analysis and Design of Dwellings Utilizing Renewable Energy Sources

Comm 22.33 General.

The requirements of Subchapter V, "Heating and Air Conditioning Equipment and Systems" and the requirements of Subchapter VI, "Dwelling Envelope Design" establish design criteria for energy-consuming and enclosure elements of the dwelling. As an alternative, an energy use analysis may be used to show equivalent compliance. The analysis shall comply with this subchapter or shall be approved by the department.

Note: The department recognizes the use of tradeoffs between higher efficiency furnaces and lower insulation levels. See appendix for an example of the UDC Energy Worksheet. Copies of the worksheet may be obtained from the Department of Commerce, Safety & Buildings Division, P.O. Box 2509, Madison, WI 53701. Other forms or software may be used when approved by the department. WIScheck software may be used to show compliance and is available from the Safety & Buildings page on the Department of Commerce Website www.commerce.state.wi.us.

Comm 22.335 Definitions. In this subchapter:

(1) “Glazing area” means the total area of the glazed fenestration measured using the rough opening and including sash, curbing or other framing elements that enclose conditioned space. For doors where the daylight opening area is less than 50 percent of the door area, the glazing area is the daylight opening area. For all other doors, the glazing area is the rough opening area for the door including the door and the frame.

(2) “Proposed design” means a description of the proposed building design used to estimate annual energy costs for determining compliance based on total building performance.

(3) “Standard design” means a dwelling whose enclosure elements and energy-consuming systems are designed in accordance with subchs. V and VI.

(4) "Substantially leak free" means the condition under which the entire air distribution system, including the air handler cabinet, is capable of maintaining a 0.1-inch water gage, or 25 Pa, internal pressure at 5 percent or less of the air handler's rated airflow when the return grilles and supply registers are sealed off, using a test method approved by the department.

Note: The department will accept tests conducted using the SMACNA HVAC Air Duct Leakage Test Manual, or other, similar test methods.

Comm 22.34 Energy analysis.

(1) Newly constructed one- and 2-family dwellings designed in accordance with this subchapter comply with Subchapters V and VI if the calculated annual energy consumption is not greater than a similar dwelling, designed as a standard design, whose energy-consuming systems and enclosure elements are designed in accordance with Subchapters V and VI**.**

Note: In this subchapter, “Standard design” means a dwelling whose enclosure elements and energy-consuming systems are designed in accordance with Subchapters V and VI.

(2) For a proposed alternate dwelling design to be considered similar to a standard design, it shall utilize the same energy sources for the same functions and have equal conditioned floor area and the same ratio of dwelling envelope area to floor area, exterior design conditions, climate data, and usage operational schedule.

Comm 22.35 Input values.

(1) GENERAL. The input values in this section shall be used in calculating annual energy performance. The requirements of this section specifically indicate which variables shall remain constant between the standard dwelling and proposed dwelling calculations. The standard dwelling shall be a base-version of the design that directly complies with the provisions of this chapter. The proposed dwelling may utilize a design that is demonstrated, through calculations satisfactory to the department, to have equal or lower annual energy use than the standard design.

(2) INPUT VALUES FOR GLAZING AND SHADING SYSTEMS. (a) *Orientation of standard design*. The orientation of the standard design shall have equal area on the north, northeast, south, southwest, east, southeast, west, and northwest exposures.

(b) *Shading calculations for proposed design.* Results from shading calculations on a proposed design may not be used for groups of buildings, unless those results constitute the worst possible building orientation in terms of annual energy use, considering all eight of the orientations under par. (a) for a group of otherwise identical proposed designs.

(c) *Exterior shading for standard design.* 1. Glazed areas in the standard design may not be provided with extra exterior shading such as roof overhangs.

2. The energy performance impacts of added exterior shading for glazing areas may be accounted for in the proposed design for a specific dwelling, provided that the actual installation of such systems is approved by the department.

(d) *Fenestration system solar heat gain coefficient, standard design.* 1. The fenestration system solar heat gain coefficient, or SHGC, inclusive of framed sash and glazing area, of the glazing systems in the standard design shall be 0.68 during periods of mechanical heating and cooling operation.

2. a. The fenestration system SHGC values shall be multiplied by interior shading values of 0.70 for summer and 0.90 for winter to arrive at an overall SHGC for the glazing system.

b. Where the SHGC characteristics of the proposed fenestration products are not known, the default SHGC values given in Table 22.35-3 shall be used for the proposed design.

(e) *Interior shading for standard and proposed designs.* 1. a. Except as specified in subd. 2., the same schedule of interior shading values, expressed as the fraction of the solar heat gain admitted by the fenestration system that is also admitted by the interior shading, shall be assumed for the standard and proposed designs.

b. The values used for interior shading shall be 0.70 in summer, and 0.90 in winter.

2. South-facing solar gain apertures on passive heating proposed designs analyzed using interior shading values for interior shading specific to those shading measures may be specified in the proposed design, with values above used in the standard design.

(f) *Passive solar designs.* Passive solar designs shall provide documentation acceptable to the department, that fixed external or other acceptable shading is provided to limit excessive summer cooling energy gains to the dwelling interior.

(3) INPUT VALUES FOR HEAT STORAGE AND THERMAL MASS. (a) Internal mass shall be 8 pounds per square foot.

(b) Structural mass shall be 3.5 pounds per square foot.

(c) Passive solar designs shall utilize at least 45 Btu/°F of additional thermal mass, per square foot of added glass area, when south-facing glass exceeds 33 percent of the total glass area in walls.

(4) INPUT VALUES FOR DWELLING ENVELOPE. (a) Surface area and volume.

1. Floors, walls and ceilings of the standard and proposed designs shall have equal areas.

2. The foundations and floor types for both the standard and the proposed designs shall be equal.

3. a. The exterior door area of the standard design shall have an equal exterior door area to that of the proposed design with a U-factor of 0.2 Btu/h. ft.^{2} ^{o}F.

b. The U_d of the standard design shall be selected to permit calculated U_o wall compliance of the standard design.

4. Building volume of both the standard and proposed design shall be equal.

(b) HVAC controls. Heating and cooling thermostats shall be set to the default settings in Table 22.35-1 for the standard and proposed designs. The input values, specific to heating and cooling controls, shall be used in calculating annual energy performance.

TABLE 22.35-1
INPUT VALUES FOR HVAC CONTROLS

Parameter	Value
Heating	68°F (20°C)
Cooling	78°F (26°C)
Set back or set up	5°F (2.8°C)
Set back or set up duration	6 hours per day
Number of set back or set up periods per unit	1
Maximum number of zones per unit	2
Number of thermostats per zone	1

(c) Internal heat gains. The input value of 3,000 Btu/hr per dwelling unit, specific to internal heat gains, shall be used in calculating annual energy performance.

(d) Domestic hot water. The following input values, specific to domestic hot water, shall be used in calculating annual energy performance:

1. The temperature set point is 120°F.

2. Daily hot water consumption in gallons = (30 x a)+ (10 x b) where a = number of dwelling units in standard and proposed designs and b = number of bedrooms in each dwelling.

(5) SITE WEATHER DATA CONSTANTS. Weather data from the typical meteorological year or its equivalent from the National Oceanic and Atmospheric Administration or an approved equivalent for the closest available location shall be used.

(6) DISTRIBUTION SYSTEM LOSS FACTORS. (a) The heating and cooling systems efficiency shall be proportionally adjusted for those portions of the ductwork located outside or inside the conditioned space using the following equations:

1. Adjusted Efficiency = Equipment Efficiency x Distribution Loss Factor

2. Total Adjusted System Efficiency = (Adjusted Efficiency x percent of ducts outside) + (Adjusted Efficiency x percent of ducts inside).

3. Distribution loss factors shall be determined using Table 22.35-2.

TABLE 22.35-2
DISTRIBUTION LOSS FACTORS

Mode	Duct Location *	
	Outside	Inside
Heating	0.75	1.00
Cooling	0.80	1.00

* Ducts located in a heated or cooled space are considered to be in an inside location.

(b) Impacts from an improved distribution loss factor, or DLF, shall be accounted for in the proposed design only if the entire air distribution system is specified on the construction documents to be substantially leak free, and is tested after installation to ensure that the installation is substantially leak free.

(c) Where test results show that the entire distribution system is substantially leak free, the seasonal DLF shall be calculated separately for heating and cooling modes using engineering methods or programs capable of considering the net seasonal cooling energy heat gain impacts and the net seasonal heating energy heat loss impacts that result from the portion of the thermal air distribution system that is located outside the conditioned space.

(d) Once these heating and cooling season distribution system energy impacts are known, the heating and cooling mode DLF for the proposed design shall be calculated using the following two equations:

1. Total Seasonal Energy = Seasonal Building Energy + Distribution System Energy Impacts

2. DLF = Seasonal Building Energy ÷ Total Seasonal Energy

(e) Once the DLF for the heating and cooling seasons are known, the total adjusted system efficiency is calculated using the following equations and conditions:

1. Adjusted System Efficiency = (Equipment Efficiency x DLF x Percent of Duct Outside) + (Equipment Efficiency x DLF x Percent of Duct Inside)

2. a. This equation shall be used to develop adjusted system efficiency for each heating and cooling system included in the standard design.

b. Where a single system provides both heating and cooling, efficiencies shall be calculated separately for heating and cooling modes.

TABLE 22.35-3
SOLAR HEAT GAIN COEFFICIENTS FOR GLAZING

PRODUCT	SINGLE GLAZED				DOUBLE GLAZED			
	Clear	Bronze	Green	Gray	Clear + Clear	Bronze + Clear	Green + Clear	Gray + Clear
Metal Frame Operable Fixed	 0.75 0.78	 0.64 0.67	 0.62 0.65	 0.61 0.64	 0.66 0.68	 0.55 0.57	 0.53 0.55	 0.52 0.54
Nonmetal Frame Operable Fixed	 0.63 0.75	 0.54 0.64	 0.53 0.62	 0.52 0.61	 0.55 0.66	 0.46 0.54	 0.45 0.53	 0.44 0.52

(7) AIR INFILTRATION. (a) For the purpose of calculation, air changes per hour for the standard design is 0.50.

(b) If the proposed design takes credit for a reduced air change per hour level, documentation of the measures providing the reduction or the results of a post-construction blower-door test conducted in accordance with ASTM E 779 shall be provided to the department. In no case shall the air exchange per hour value be less than 0.20.

Comm 22.36 Design. The standard design and the proposed alternative design shall be designed on a common basis as specified in this section:

(1) The comparison shall be expressed in Btu input per square foot of gross floor area per year or other time unit, at the dwelling site.

(2) If the proposed alternative design results in an increase in consumption of one energy source and a decrease in another energy source, even though similar sources are used for similar purposes, the difference in each energy source shall be converted to equivalent energy units for purposes of comparing the total energy used.

(3) The different energy sources shall be compared on the basis of energy use at the dwelling site where 1 kWh = 3,413 Btu.

Comm 22.37 Analysis procedure. The dwelling heating and cooling load calculation procedures shall be detailed to permit the evaluation factors specified in s. Comm 22.38 to provide a comparison of energy consumption between the alternative design and the standard design.

Comm 22.38 Calculation procedure.

The calculation procedure shall cover all of the following items that are expected to have a significant impact on the comparison of the energy consumption between the alternate design and the proposed design:

(1) Environmental design requirements as specified in Subchapter IV.

(2) Coincident hourly climatic data for temperatures, solar radiation, wind and humidity of typical days in the year representing seasonal variation.

(3) Dwelling orientation, size, shape, mass and volume.

(4) Air, moisture and heat transfer characteristics.

(5) Operational characteristics of controls for inside air temperature, humidity, ventilation, lighting, and the control mode for occupied and unoccupied hours.

(6) Mechanical equipment design capacity load profile.

(7) Dwelling loads of internal heat generation, lighting, equipment, and the number of occupants during occupied and unoccupied periods.

Comm 22.39 Use of approved calculation tool.

The same calculation tool or method shall be used to estimate the energy usage for space heating and cooling of the standard design and the proposed design. The calculation tool or method and the documentation shall be approved by the department.

Comm 22.40 Documentation.

Proposed alternative designs submitted as requests for exception to the standard design criteria shall be accompanied by an energy analysis comparison report. The report shall provide technical detail on the two dwellings, system designs, and data used in and resulting from the comparative analysis verifying that both analysis designs meet the criteria of this chapter.

SAMPLE

Date:

Owner's
Property
Address:

Builder's
Weather
Builder's

Element

Roofs/Ce
Above-G
Slab Floo
Basemer

OVERAL

This DES
Code. (C

This REN
conserva

Building
Roof/Cei
Roof
Above-G
Wall
Joist
Joist
Windo
Windo
Windo
Windo
Windo
Door
Slab Floo
Expos
Baseme
Wall
Wall

HOME PERFORMANCE RATING

REM/Rate v8.46 - Wisconsin

home
PERFORMANCE

SAMPLE

Uniform Dwelling Code Compliance Option Reports

For more information contact:

Home Performance Rating
211 South Paterson Street
Madison, WI 53703
1-800-677-8423
Fax 608-249-0339

SAMPLE

Wisconsin Uniform Dwelling Code Compliance By Annual Energy Analysis

Date:	January 04, 1999	Rating No.:	
Owner's Name:	UDC4	Rating Org.:	
Property		Phone No.:	
Address:	Milwaukee, WI	Rater's Name:	
		Rater's No.:	
Builder's Name:			
Weather Site:	Milwaukee, WI	Rating Type:	Based On Plans
Builder's File:	UDC42.BLG	Rating Date:	

Annual Energy Consumption (MMBtu)

	UDC	As Designed
Heating:	97.6	89.1
Cooling:	4.6	4.8
Total:	102.2	93.9 *

This DESIGN meets the annual energy consumption requirements of the Wisconsin Uniform Dwelling Code. (COMM Chapter 22, Subchapter VII.) Surpasses UDC requirements by 8%

This REM/Rate report is a Department of Commerce approved method of showing compliance with the energy conservation standards of Chapter COMM 22 of the Uniform Dwelling Code.

* Design consumption is based on the following heating/cooling system:
  Heating: Fuel-fired air distribution, 60.0 kBtuh, 78.0 AFUE.
  Cooling: Air conditioner, 24.0 kBtuh, 10.0 SEER.

In accordance with the Uniform Dwelling Code, building inputs such as setpoints, infiltration rates, and window shading may have been changed prior to calculating annual energy consumption.

SAMPLE

SAMPLE

EQUIPMENT SIZING SUMMARY

Date:	January 04, 1999	Rating No.:	
Owner's Name:	UDC4	Rating Org.:	
Property		Phone No.:	
Address:	Milwaukee, WI	Rater's Name:	
		Rater's No.:	
Builder's Name:			
Weather Site:	UDC Design Zone 4, WI	Rating Type:	Based On Plans
Builder's File:	UDC42.BLG	Rating Date:	

	udc42
HEATING	
Calculated Peak Load (kBtu/hr)	48.2
Oversize Factor (%)	115.0
HEATING EQUIPMENT CAPACITY (kBtu/hr)	
Calculated	55.4
Specified	60.0
COOLING	
Calculated Peak Load (kBtu/hr)	21.0
Sensible	17.0
Latent	4.0
Oversize Factor (%)	100.0
COOLING EQUIPMENT CAPACITY (kBtu/hr)	
Calculated	21.0
Specified	24.0
SENSIBLE HEAT FRACTION (SHF)	
Calculated	0.81
Specified	0.70

Heating equipment capacity calculated using Wisconsin Uniform Dwelling Code ambient design temperature. (COMM Chapter 22, Subchapter IV, Table 22.07-2.) Indoor set points used: Heating 68.0 Cooling 78.00

REM/Rate - Residential Energy Analysis and Rating Software v8.46 Wisconsin

This information does not constitute any warranty of energy cost or savings.

SAMPLE

ENERGY COST AND FEATURE REPORT

Date:	January 04, 1999	Rating No.:	
Owner's Name:	UDC4	Rating Org.:	
Property		Phone No.:	
Address:	Milwaukee, WI	Rater's Name:	
		Rater's No.:	
Builder's Name:			
Weather Site:	Milwaukee, WI	Rating Type:	Based On Plans
Builder's File:	UDC42.BLG	Rating Date:	

ANNUAL ENERGY COSTS		udc42
Heating	$	512
Cooling	$	106
Water Heating	$	128
Lights & Appliances	$	461
Service Charges	$	114
Total	$	1321
Average Monthly	$	110

ENERGY FEATURES	
Ceiling w/Attic	R38 Attc (2x4 24oc) U=0.026
Vaulted Ceiling	None
Above Grade Walls	R19 (2x6 16oc) R5 U=0.043
Foundation Walls	R-10.0
Doors	R-1.7 w/storm
Windows	D W Op (LoE/Ar HC) U=0.390
Window Shading	H: Some C: Some
Frame Floors	None
Slab Floors	UninsulatedR-0
Infiltration	H: 7.50 C: 7.50 ACH50
Infilt. Measure	Blower door test
Interior Mass	None
Heating System	Fuel-fired air distribution
Heating Efficiency	78.0 AFUE
Cooling System	Air conditioner
Cooling Efficiency	10.0 SEER
Water Heating System	Conventional, Gas
Water Heating Efficiency	0.58 EF
Ducts	Uninsulated
Active Solar	None
Sunspace	No

Notes: Where feature level varies in home, the dominant value is shown.

REM/Rate - Residential Energy Analysis and Rating Software v8.46 Wisconsin

This information does not constitute any warranty of energy cost or savings.

Permit #
Checked by/Date

WIScheck COMPLIANCE REPORT
Wisconsin Uniform Dwelling Code
WIScheck Software Version 1.0

TITLE: UDC Chapter 22 Compliance Example

COUNTY: Dane
HEATING TYPE: Non-Electric
DATE: 1-4-1999
DATE OF PLANS: 1/4/99
PROJECT INFORMATION:
1500 ft2 house in Dane County

Sample Report

COMPANY INFORMATION:
Builder's Business Name

NOTES:
Windows are certified by NFRC. See attached manufacturer's specifications.

UDC COMPLIANCE: PASSES

Required UA = 373
Your Home = 349
6.5% Better Than Code

	Area or Perimeter	Cavity R-Value	Cont. R-Value	Glazing/Door U-Value	UA
CEILINGS	1500	19.0	19.0		39
WALLS: Wood Frame, 16" O.C.	1316	13.0	5.0		84
WALLS: Wood Frame, 16" O.C.	151	13.0	5.0		10
BSMT: Conc. 8.0' ht/7.0' bg/8.0' insul	1468	0.0	5.0		132
GLAZING: Windows or Doors, Above Grade	75			0.350	26
GLAZING: Windows or Doors, Above Grade	75			0.370	28
GLAZING: Windows, Basement/Foundation	20			0.870	17
DOORS	38			0.350	13
HVAC EQUIPMENT: Furnace, 90.0 AFUE					

COMPLIANCE STATEMENT: The proposed building design described here is consistent with the building plans, specifications, and other calculations submitted with the permit application. The proposed building has been designed to meet the requirements of the Wisconsin Uniform Dwelling Code.

Builder/Designer______________________________ Date____________

WIScheck Report Sample

TITLE: UDC Chapter 22 Compliance Example

Heating Equipment Sizing Summary

General Information

Outdoor Design Temperature:	-15	deg
Conditioned Floor Area:	1500	ft2
Average Ceiling Height:	8.0	ft
Infiltration Rate:	0.50	Normalized ACH
Equipment Oversizing Factor:	15.0	%

Loads Summary

Conductive Losses:	29725	Btu/hr
Infiltration Losses:	9180	Btu/hr
Oversizing Factor Losses:	5836	Btu/hr
Total Building Heating Load:	44741	Btu/hr

WIScheck Report Sample

Comm 22.41 Renewable energy source analysis.

(1) A proposed dwelling utilizing solar, geothermal, wind or other renewable energy sources for all or part of its energy sources shall meet the requirements of s. Comm 22.33, except such renewable energy may be excluded from the total annual energy consumption allowed for the proposed dwelling by this subchapter.

(2) To qualify for the exclusion in sub (1), the renewable energy must be derived from a specific collection, storage, and distribution system. The solar energy passing through windows shall also be considered as qualifying if such windows are provided with one of the following:

(a) Operable insulation shutters or other devices which, when drawn or closed, cause the window area to reduce maximum outward heat flows to those in accordance with s. Comm 22.31 (2), and the windows are shaded from direct solar radiation during periods when mechanical cooling is requested.

(b) The glass is double or triple pane insulated glass with a low-emittant coating on one or both surfaces of the glass, or insulated glass with a low-emittant plastic film suspended in the air space, and the glass areas are shaded from direct solar radiation during periods when mechanical cooling is requested.

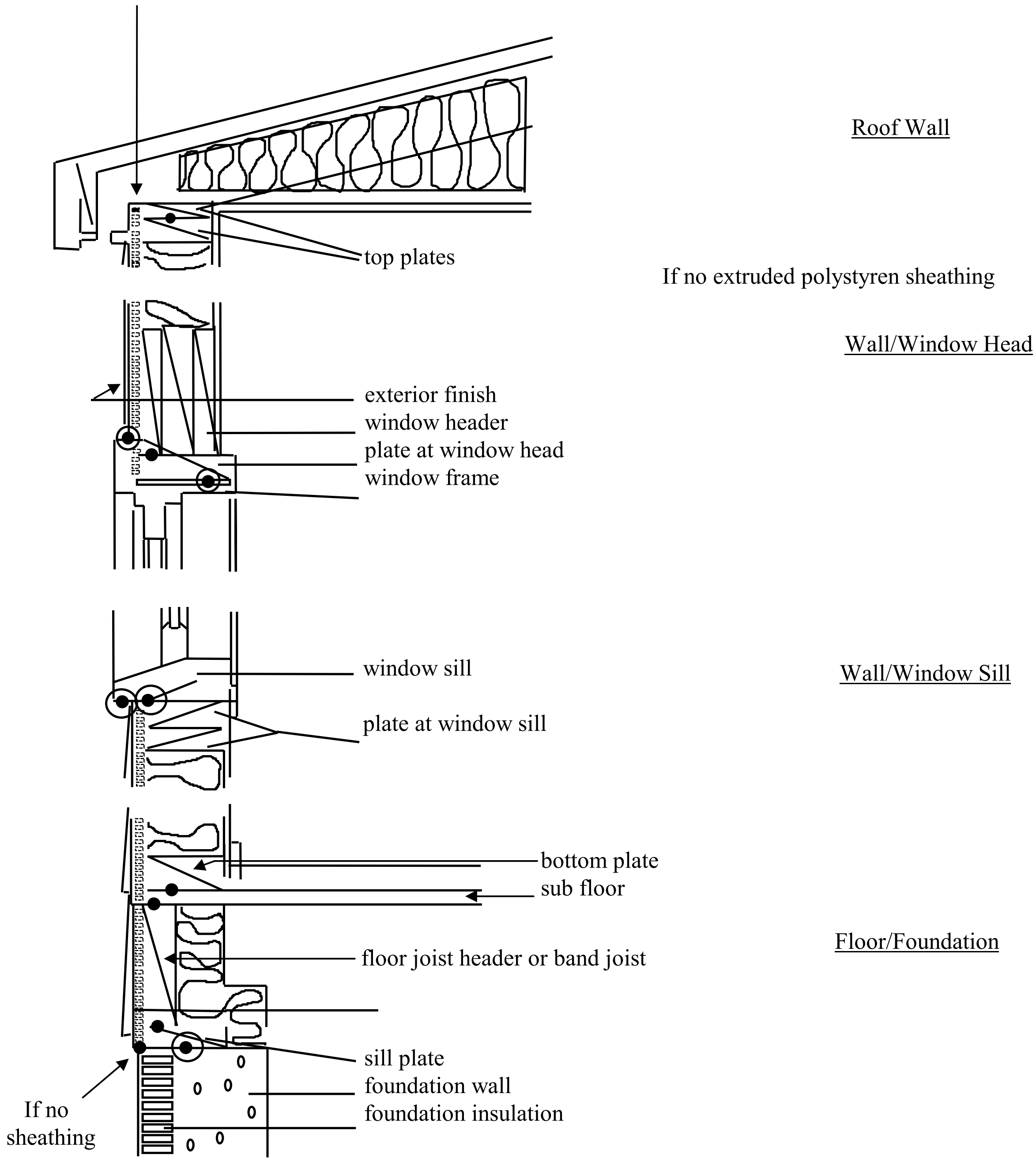
(3) Other criteria covered in s. Comm 22.23 to 22.39 shall apply to the proposed alternative designs utilizing renewable sources of energy.

Comm 22.42 Documentation.

(1) Proposed alternative designs submitted as requests for an exception to the standard design criteria, shall be accompanied by an energy analysis, as specified in s. Comm 22.40. The report shall provide technical detail on the alternative dwelling, system designs, and the data employed in and resulting from the comparative analysis to verify that both the analysis and the designs meet the criteria of this code.

(2) The energy derived from renewable sources and the reduction in conventional energy requirements derived from nocturnal cooling shall be separately identified from the overall dwelling energy use. Supporting documentation on the basis of the performance estimates for the renewable energy sources and nocturnal cooling means specified in this subchapter shall be submitted to the department.

s\sb\commentaries\ch22

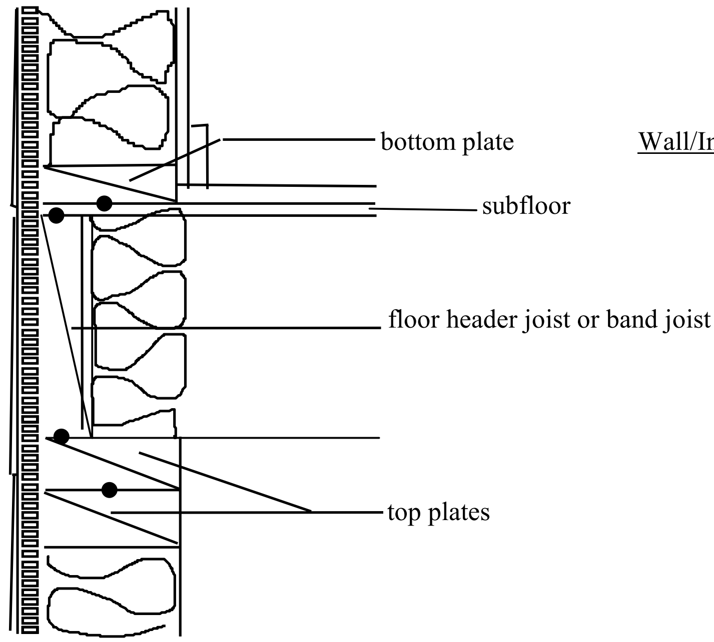


Caulk, Gasket or Seal:

Mandatory; also (not shown):

- All utility penetrations
- Between door thresholds and subfloor
- Between joist header and foundation
- Exterior joints at cantilevered floors, bay windows and soffitts (floor to wall, wall to roof, but not wall to wall joints)
- Separate wall panels in panelized construction

<u>Wall/Intermediate Floor</u>



<u>Wall/Foundation</u>